Experimental Data on Transmitter and Receiver Reflectance Parameters

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Supporters

- To Be Added

Reference in this contributions

“Data to Support 100G Optical Parameter Selection”

http://www.ieee802.org/3/ct/public/19_05/schmitt_3ct_01a_0519.pdf

Introduction

- IEEE P802.3ct draft has been issued, and some parameter values are TBD.

- This contribution proposes transmitter and receiver reflectance values in Tables 154-8 and 154-9 respectively for 100GBASE-ZR with supporting experimental data.

Table 154-8

Table 154–8—100GBASE-ZR transmit characteristics

Description	Value	Unit
Signaling rate (range)	27.9525 ± 20 ppm	GBd
Modulation format	DP-DQPSK	—
Minimum channel spacing	100	GHz
Average channel output power (max)	TBD	dBm
Average channel output power (min)	–8	dBm
Nominal center frequency	The frequency in Table 154–6 corresponding to the variable Tx_optical_frequency_index	THz
Spectral excursion (max)	±15	GHz
Side-mode suppression ratio (SMSR), (min)	30	dB
Laser linewidth (max)	1000	kHz
Offset between the carrier and the nominal center frequency (max)	1.8	GHz
Power difference between polarizations (max)	1.5	dB
Skew between the two polarizations (max)	TBD	ps
Error vector magnitude (max)	23	%
I-Q offset (max)	–25	dB
Transmitter OSNR(193.6) (min)	35	dB
Average launch power of OFF transmitter, each lane (max)	TBD	dBm
Optical return loss tolerance (max)	TBD	dB
Transmitter reflectance[a] (max)	TBD	dB

[a]Transmitter reflectance is defined looking into the transmitter.

Table 154-9

Table 154–9—100GBASE-ZR receive characteristics

Description	Value	Unit
Signaling rate (range)	27.9525 ± 20 ppm	GBd
Modulation format	DP-DQPSK	—
Nominal center frequency	The frequency in Table 154–6 corresponding to the variable Rx_optical_frequency_index	THz
Damage threshold[a]	TBD	dBm
Maximum average input power	0	dBm
Minimum average input power [amplified]	–16	dBm
Minimum average input power [unamplified]	–30	dBm
Minimum OSNR(193.6) [amplified]	19.5	dB (0.1 nm)
Minimum OSNR(193.6) [unamplified]	35	dB (0.1 nm)
Receiver OSNR tolerance(193.6)	16.5	dB (0.1 nm)
Receiver reflectance (max)	TBD	dB

[a]The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level. The receiver does not have to operate correctly at this input power.

Reflections

- Reflections are caused by differences in the refractive index at an interface point
  - A signal reflects off of the interface and back toward its source at reduced power
- When there are multiple reflections, both the original signal and the reflected signal will reach the receiver
  - This can lead to interferometric noise at the receiver
- As a result, it is important to ensure that the reflected signal reaching the receiver has been reduced sufficiently to avoid creating significant interference

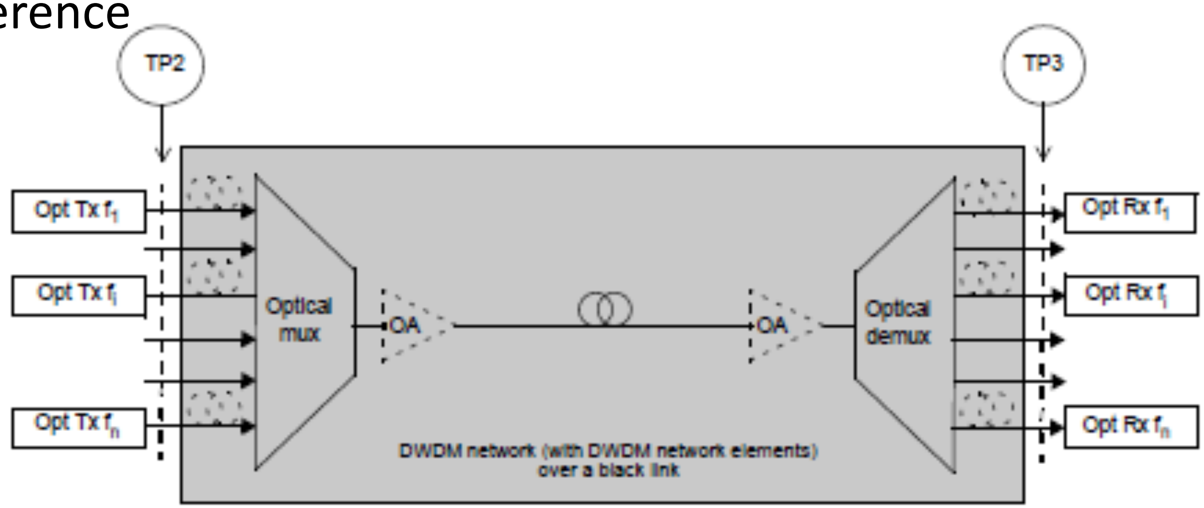


Figure 154–3—Block diagram for black link specification approach

Reflections Example

- Signal is transmitted from Optical Transmitter Tx1
- A portion of that signal is reflected by the Optical Mux back toward the transmitter
- A portion of that signal is then reflected by the Optical Transmitter
- This “double reflected” signal then travels to the Optical Receiver Rx1, where it is seen as interferometric noise
- Reflected signal power is determined by reflectance performance of **both the optical mux input and the transmitter output**

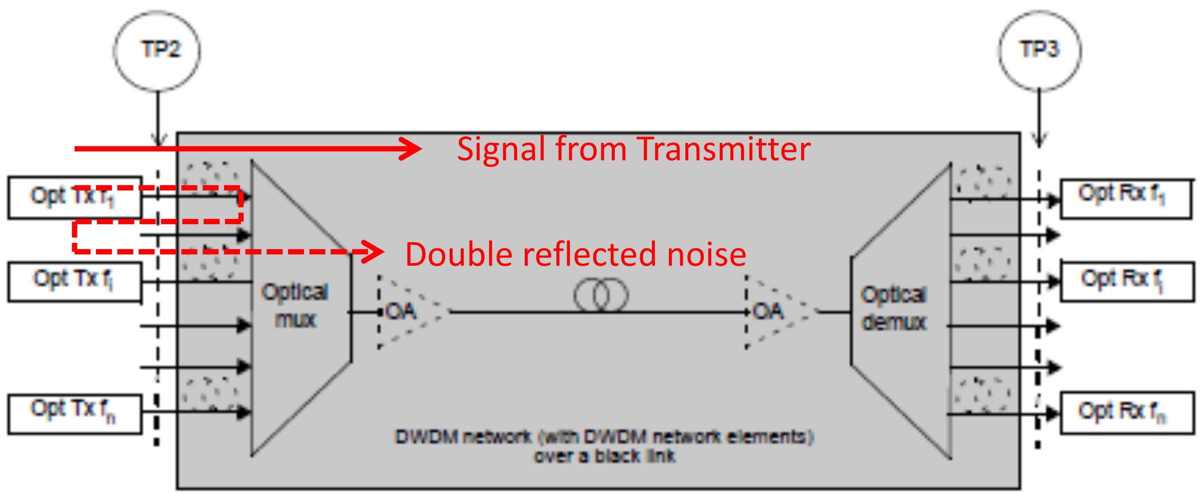


Figure 154–3—Block diagram for black link specification approach

Optical MUX Reflectance

- Optical mux/demux connectors have a similar refractive index to optical fiber
  - As a result, they reflect very little signal
- Based on current product performance, a reasonable assumption for reflectance of these connectors is -40 dB
  - In other words, the reflected signal is 40 dB lower than the incident signal
- This analysis uses -40 dB for the reflectance performance of the mux/demux interface

Transmitter Reflectance

- Current and next generation small form factor pluggable optics use new materials to lower cost and improve performance
  - For example, Silicon Photonics (SiP) and Indium Phosphide (InP)
- They therefore have larger refractive index differences
  - Results in higher reflectance at the optical interface
- In order to allow the use of these materials and keep costs as low as possible, need to allow greater reflectance at the optical interface
  - ITU-T has historically specified -27 dB for module reflectance
  - The modules generally did not use FEC
  - However, this is challenging to meet cost effectively with new materials
- CableLabs and OIF have more recently specified -20 dB in order to enable these new designs and keep costs low
  - Following example examines how this impacts reflected signal

Reflections Example with Numbers

- Signal is transmitted from Optical Transmitter Tx1
- A portion of that signal is reflected by the Optical Mux back toward the transmitter
  - Reduced by 40 dB
- A portion of that signal is then reflected by the Optical Transmitter
  - Reduced by an additional 20 dB
- Therefore, the interferometric noise reaching the receiver is 60 dB lower than the original signal

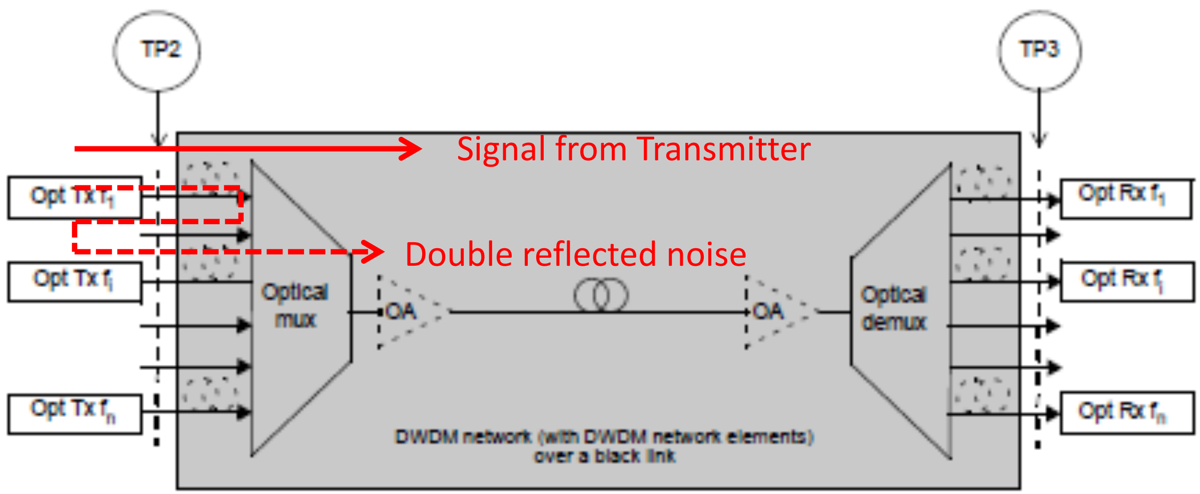
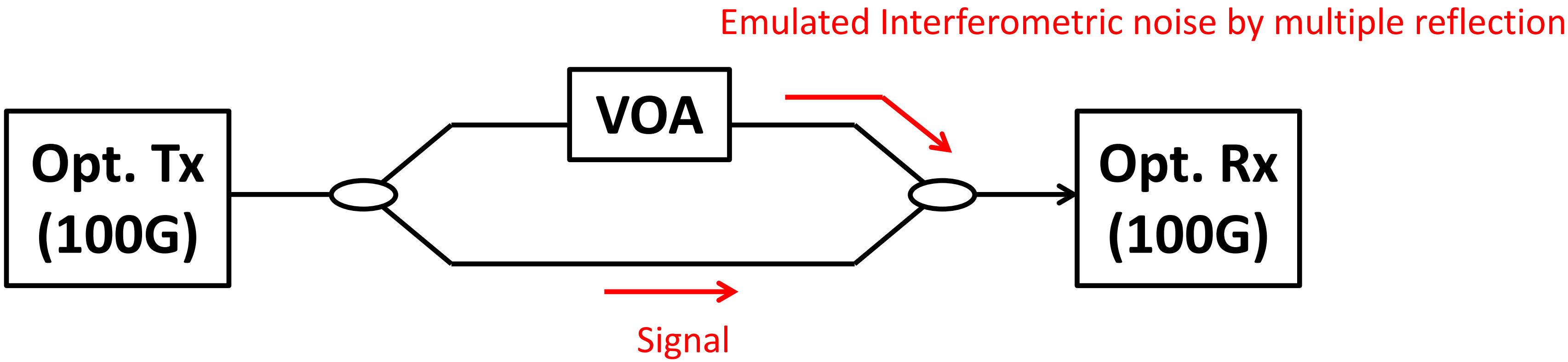


Figure 154–3—Block diagram for black link specification approach

Comparison with ITU-T Requirement

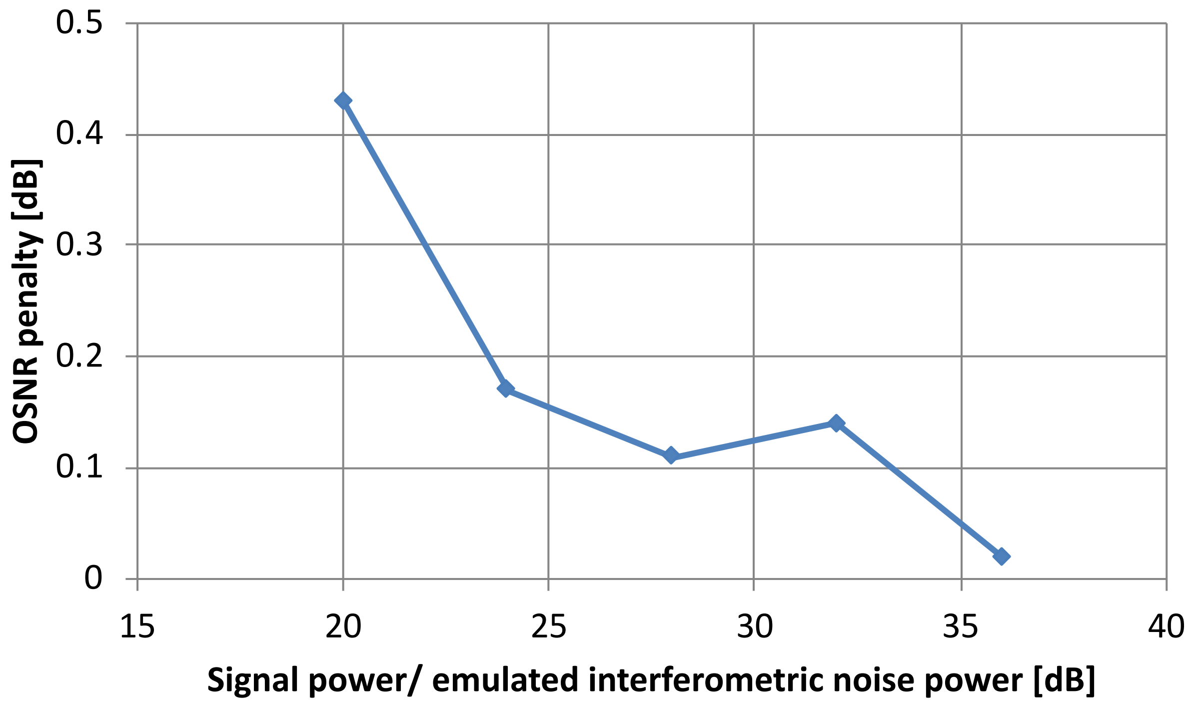
- As shown in the example, using a reflectance of -20 dB, the interferometric noise that reaches the receiver is 60 dB lower than the received signal
- If the ITU-T requirement of -27 dB were used, the interferometric noise would be 67 dB lower instead of 60 dB lower than the received signal
- Therefore, set out to determine if there was any appreciable difference in performance between those two numbers experimentally

Experimental setup



- We evaluated interferometric noise impact on 100G systems by above test setup
- Optical signal from transmitter is split by an optical coupler
  - One output of the coupler is attenuated by VOA and combined with the other to **emulate interferometric noise** by reflection
- Measured OSNR penalty (using Staircase FEC) by changing ratio of signal power to emulated reflection noise power

Experimental results



- When the interferometric noise was greater than 35 dB lower than the signal, the OSNR penalty was less than 0.05 dB
- Therefore, we can conclude that:
  - The OSNR penalty for interferometric noise that is 60 dB lower is negligible
  - The difference between 60 dB and 67 dB lower is negligible

Receiver Reflectance

- Note that the examples and experimental data also apply for receiver reflectance
- In this case, the incident signal reflects off the receiver, lowering it by 20 dB
- That signal then reflects off of the mux/demux port, lowering it by an additional 40 dB
- Therefore, the interferometric noise reaching the receiver due to receiver reflectance is also 60 dB lower than the original signal, as was the case with transmitter reflectance

Conclusions

- In order to keep costs lower and allow the use of new materials and technologies, we need to adopt transmitter and receiver reflectance values that are greater than what has been used in the past
- Based on the experimental data, adopting a reflectance value of -20 dB for the transmitter and the receiver will not affect performance in a meaningful way relative to the ITU-T requirement of -27 dB reflectance
- We therefore propose adopting the following values:
  - Transmitter Reflectance (max): -20 dB (in Table 154-8)
  - Receiver Reflectance (max): -20 dB (in Table 154-9)